Combining Web and Mobile technologies to Support Sustainable Activity Design in Education.

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Abstract: In this paper, we describe an approach for designing and developing technological solutions to support teachers in creating their own outdoor teaching activities. We elaborate on one particular case, TriGO, in which primary school students perform outdoor tasks to experience concepts and constructions in the field of mathematics. The application designs and an initial evaluation of the developed technological solutions is provided based on the results obtained from school activities performed with more than 10 teachers and 50 students.

Keywords: ubiquitous learning, web authoring tool, mobile development

Introduction

An open challenge in Technology Enhanced Learning (TEL) is the design of ICT solutions to support seamless learning (Milrad et al., 2013) that could allow learning across time, locations and devices. Teachers have not enough knowledge and sometimes lack support in how to use ICT in their daily teaching activities. This seamless gap provokes that teachers have low beliefs in the technology potential in education (Ertmer, 2012). As a result and despite the potential benefits new technologies offer, teachers come back to traditional teaching methods. Additionally, user-created content is expected to grow in the future (Martin et al., 2011). For instance, teachers will be able to create and adapt content to fit into their pedagogical and physical context. These visions point out also to the need of offering IT tools and methods to support the enactment of seamless learning.

Our focus in this paper is to provide some initial guidelines aiming at software developers and educational technologists on how to design ICT solutions that can support teachers in creating seamless learning activities and reduce the programming skills requirements to develop such solutions. In our approach, we combine mobile and web technologies for the design of learning activities that combine working indoor and outdoor. From a teacher perspective, each activity includes a phase for design, an outdoor experimentation phase, and an indoor follow-up reflection phase in which the learning outcomes are expected to be wrapped up. We provide one concrete example, TriGO[1], and describe the application design and the results of an initial evaluation on the developed technology based on school sessions performed with more than 10 teachers and 50 students. A deeper analysis will proceed in the coming months, in which we expect to evaluate the technology through multiple schools involving several regions and countries.

Background

During the last 5 years, our research group has conducted research studies with the focus of TEL to be applied within the field of mathematics and with special interest in geometry (Gil et al., 2015). These activities involve use of mobile technologies outdoors, allowing students to explore the mathematic concepts in authentic settings and support the traditional lectures with the experiences gained in the field. GEM (GEometry Mobile) (Sollervall & Gil, 2015; Gil et al., 2015) is one example of these studies. In GEM, students from 4th to 6th grade have participated in activities in which they used GPS-enabled mobile devices to explore spatial orientation based on landmarks on a field via triangulation to engage the students in triangle-based constructions.

From our previous experiences, we have learnt that mobile technologies can support a reflection and discussion process that allows the students to understand concepts in the field of geometry, and teachers have shown capability to make efficient use of the provided software (Sollervall and Gil, 2015). However, the adoption of mobile technologies does not suffice to fulfill the requirements for a seamless learning activity. The application must be able to transfer the data that has been gathered in groups in the outdoor phase (via mobile phones) to a reflection phase that can be performed by the whole class in the classroom environment (via a desktop computer). Teachers cannot be expected to hold software development skills that would be needed for transferring the data between different devices and to create tools that can process these data for supporting follow-up discussions. Therefore, their dependency on researchers and software developers becomes a limitation

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[1] http://trigo.lnu.se

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for their future independent use of the technologies. To address this gap, we designed TriGO, as an evolution of GEM, and we reflect on our experiences to identify a number of technological requirements that are needed to support the activity's didactical goals. We divide an activity in three main phases, *Design*, *Experimentation* and *Reflection* based on the model "Activity plan, Field trip and Reflection" (Krepel and DuVall, 1981). The Experimentation phase begins with an *Introduction* phase in which the teacher introduces the activity to the students.

Application Design

We want to create an ICT solution that supports seamless learning across locations and devices in order to encompass informal (outdoor phase) and formal (indoor follow-up phase) learning phases (Milrad et al., 2013). The Design, Introduction and Reflection phases are handled indoors with desktop computers, while the Experimentation phase is executed outdoors by making use of mobile devices. Even though the following descriptions refer to the TriGO application, the reader will find the structure reusable to create other seamless learning activities in which design, experimentation and reflection phases are desired.

Although technological tools for education are designed to support achieving specific learning goals, teachers still need to customize the tools to their specific settings. In the case of TriGO, the application requires specifying the location in which the activity will take place, in order to define the coordinates of six landmarks that are used for the triangulation tasks. To facilitate this process, we have developed a web-based authoring tool (Fig. 1-a) that allows teachers to specify the activity location in a map using simple interaction methods (such as drag and drop, search for addresses, rotate and zoom) without requiring any programming skills. These functionalities guarantee that the activity takes place at the exact desired location. The created activity can later be displayed to introduce the students to the activity (Fig. 1-a).

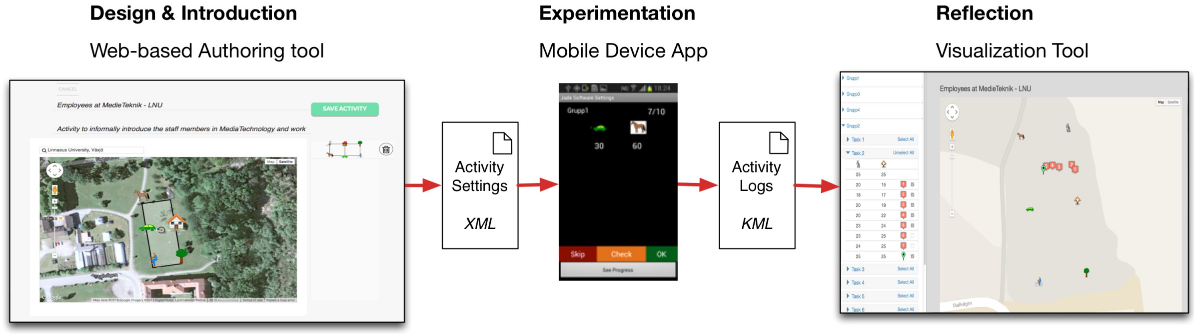

Figure 1. The tools in TriGO: a) Web-Authoring tool. b) Mobile app. c) Visualization tool

After specifying the context of the activity, fourteen *activity settings XML* files are created. Each XML file is used by the mobile application as a configuration file to run the activity on the field. These files are divided into two sections. The first section reflects the customization of the activity that the teacher has defined via the authoring tool. This section specifies the location of the six markers on the field (see Fig. 1-a). The second section contains a list of 10 points (and their distances to the markers in the first section) that the students need to find through triangulation. The ten points in this second part reflect a dedicated study in math-didactics to select tasks that are both challenging and promote exploration and reflection. The fourteen activity settings files have equivalent pedagogical tasks, but their design has been studied to avoid simultaneous coincidences. This prevents that the students mimic their colleagues' actions and requires them to reason about their own performance. The authoring tool also offers a Dashboard environment for the management and coordination of the groups. It allows monitoring that the XML files are downloaded by the students via the mobile application in order to ensure that the *Experimentation* phase will be able to take place.

The second tool in TriGO (Fig. 1-b) offers capabilities for mobility and exploration that the students require for the *Experimentation* phase, i.e. spatial orientation and triangulation tasks. During the execution of this phase, the mobile application uses the GPS module to get the students geo-location and calculate the student's distance from the landmarks on the field. The interested reader can find more information regarding the mobile application design and behavior at (Gil et al., 2015). During our years of experience in the GEM activities, we have learnt that mobile applications should contain the minimum necessary information to be able to perform and support the learning activity. This becomes even more important when kids are the users of these applications. An excess of information becomes distractive to the student, who can loose focus on the learning activity. On the other hand, lacking information on the mobile device application can be seen as a challenge for the student, but it can also provoke the student frustration. Our mobile application has been designed relying on simple interaction methods and reducing the amount of information on the display to the minimum. Fig 1-b shows the application interface that displays only the information for task at hand (which comprises the two required points for triangulation, car and horse in the Fig. 1-b, and the distances to these points, 30 and 60 meters respectively). On prior versions of our mobile device application, it was required to manually upload the *activity settings XML* files to mobile devices via USB connections. With seamless interaction on mind, the mobile device application has been designed to retrieve the *XML* file from the authoring tool simply entering an activity identifier (that the teacher must give to the students). Also on prior versions, it was necessary to manually retrieve the *activity log* from the mobile devices to a desktop environment, in order to process the information in the logs and support the follow-up discussion. Also with seamless multiple device interaction on mind, the mobile application can upload the logs to the server side by a single click on the display.

The third and last tool refers to the *Reflection* phase. The main objective of this phase is to support discussions and reflections through two visualization techniques (Fig. 1-c). This tool has been conceptualized to show the actions performed during the outdoors activity. In order to do so, this tool requires the *activity log* generated by the mobile application. On the left side (Fig. 1-c), the tool is designed to present the information in a numerical way. Using a tree structure that organizes the multiple attempts in group-activity-task-attempt, the students can observe the different measurements that they performed during the *Experimentation* phase. On the right side, the tool present the information graphically on a map, which supports the numeric values with contextual (location) information. Having the different actions plotted in a map can be helpful for describing the actions that the students executed during the outdoors activity (Sollervall & Gil, 2015). In a first version, we have used Google Earth to offer the visualizations we described. A second version of the visualization block has being developed using web-tools, in order to increase the tool's usability and enhance features that such a tool requires, such as a logging tool that will allow studying the pedagogic discussions that take place while using the visualization tool.

Assessment

The development of the three blocks of the TriGO application has been performed at different stages and following an iterative development method. Therefore, we have run assessment studies independently for each one of the three blocks of the activity in order to study their usability.

The authoring tool created for TriGO was developed guided by the results obtained from a prior study in the use of generic authoring tools. In a prior study, a generic authoring tool was presented in several workshops with a total of 29 teachers in the area of Kronoberg, Sweden. Through the study, we aimed at identifying, first, the user's experiences in using web technologies for designing activities and, second, their specific needs for creating learning activities. The results showed that teachers with limited technical skills rapidly learned how to make use of the authoring tool functionalities and did not have difficulties to use the web-technologies to design their own learning activities. The TriGO authoring tool was later presented to a group of ten teachers from different regions in Sweden. The results from this presentation were also aligned to our prior experiences demonstrating authoring tools, which demonstrates that the web-based solution is a convenient approach for letting teachers design their own learning activities and enables them to coordinate the preparation for the outdoor phase via the dashboard. Additionally, the web-based solution reduces potential application installation issues. It is important to notice that teachers in schools may not have administration privileges that could be required to install some new learning applications.

The mobile application has evolved through the case studies we performed during the last 5 years (Gil et al., 2015; Sollervall and Gil, 2015). In our most recent version, the TriGO mobile application has been used in two different sessions by 27 students in 4th grade and 26 students in 6th grade. In order to study the application usability in authentic settings, in which the schools will not have access to the research team, the students did not have prior training in how to use the mobile application and interactions with researchers were avoided. The first contact that the students had with the TriGO mobile application was ten minutes before the *Experimentation* phase, in which the teacher handled the phones while describing that they were going to participate in a mathematics activity using mobile devices. Based on the recordings, the students did not have difficulties to interact with the mobile application interface, neither to understand the activity flow and how to proceed during the session. Additionally, the seamless interaction between the mobile device and the web application reduced the complexity and time required to prepare the mobile devices for the outdoor phase and to retrieve the logs from the mobile devices for the follow-up phase. This interaction offers a seamless transition between locations and devices (Milrad et al. 2013).

However, in two cases, the mobile devices provided inaccurate GPS locations that lead to incorrect distance values that did not reflect real distances on the field. In these cases, the students demanded the teacher's involvement to assist them with the mobile application or to reassign them to other teams. An alternative approach to deal with failing resources consists on implementing auto-recovery mechanisms that correct undesired device status, as presented in (Gil et al. 2015). Based on our observations, the application's simplicity and its high responsiveness in providing the distance measurements for each attempt have been key aspects for achieving satisfactory usability results.

The concepts regarding the visualization tool have been studied through the two sessions that followed the *Experimentation* phase, which were also recorded for later analysis. For these sessions, we used Google Earth to provide the visualization needed for the discussions. The visualizations were presented on a whiteboard via a projector. For the sessions, we did not offer prior recommendations to the teachers in how to use the visualization tools in their discussions. For the session with 4th grade students, the visualization tool was used to show the different attempts on the map. The tool was supportive for the students presenting their ideas and referring to actions that they did on the field. The teacher could lead the conversations by selecting which specific student cases should be displayed and encouraging all the students to go to the whiteboard for presenting their ideas. In comparison, the tool was used in a different manner in the session with the 6th grade students. The discussions led by the teacher were based only on the numerical representation of the actions (left side of the visualization tool), and no interactions were done on the map representation. For this group of students, the numerical visualization fits better with the curriculum and increases the level of abstraction that it is required for discussing mathematical concepts.

Conclusions and Future Challenges

In this paper, we have presented an approach for designing technological solutions to support teachers in creating their own outdoor teaching activities. These activities support a seamless learning experience across locations, times and devices via the combination of mobile and web technologies. Based on our experiences, we have defined a set of guidelines that can be useful for software developers to design applications that support seamless learning across locations, time and devices. We advocate the use of web-based authoring tool solutions to allow teachers to create, adopt and adapt learning activities that connect the physical and the digital worlds. Connecting these authoring tools to mobile devices can make seamless transitions across locations and devices and offer the users the possibility to explore learning context in informal settings. The same way, mobile devices should allow seamless connections back to web-technologies, in order to bring spaces for students to have common reflection and discussions. Furthermore, we suggest the use of visualization tools that offer several types of data presentation method. Our Experimentation phase demonstrated to be supportive for the pedagogical discussions and complementary in their purposes, and the two data presentation methods using in our visualization tool have allowed the teachers to direct the discussions using different strategies that fit the needs for each particular group of students. The outcomes of our efforts show also that the combination of these technologies can simplify the challenges that teachers currently face while desiring to create activities that cover their specific needs. This combination benefits from using the particular strengths of each complementary technology. Additionally, web-based solutions remove the need to install additional software on the teacher's personal computer, school computers or the used mobile devices. Regarding these application interfaces, these should be designed to be simple and responsive, in order to avoid disturbing the learning objectives of the activity. Finally, the application robustness is a critical aspect that must be considered and it can be addressed by means of using auto-recovery mechanisms as presented in (Gil et al. 2015).

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